

Review on Preparation of Low cost Adhesive from Waste Material using Citrus Fruits.

Dr. Satyajit M Deshmukh¹, Dr Vrushali N Raut² and Mr. Prashant M Ingole³

^{1,2,3}*Datta Meghe College of Engineering Airoli Navi Mumbai*

Abstract-

In today's life many ecological problems are becoming an issue. Polystyrene is one of the environmental affecting materials which is non- biodegradable. Thus discovery ways to reprocess it would be helpful in reducing the harm caused by this material. By turning a thermocol into a good quality glue using the citrus fruits skin like orange, lemon, sweet lemon & following an easy procedure. The growing of bio based adhesive without destructive chemical agents is very significant for the upcoming. Adhesives prepared by this method are non-toxic and having a good tensile strength. This promotes recycling of waste materials. This sort of adhesive, which is non-toxic and made from waste, could be used as an alternative source. This glue will be very cheap than other glues present in the market. This glue may be used for stationary works such as sticking papers and many other small type of stationary works.

Key Words: Adhesives, Polystyrene, Citrus fruits

Introduction

An adhesive is also named as, glue, cement, mucilage or paste. [2] [10] Adhesive is non-metallic substance which applied on either single or both the surfaces of two items which is to be joined together and it oppose their separation. [2] [11] The usage of adhesives has many benefits over a binding technique such as stitching, motorized clasp, thermal bonding, etc. these all has the ability attach to different material together, distribute the stress effectively over the joint, it used to develop the aesthetic design, and it improves the design flexibility.[2] [12]

Adhesives of various types have been used from the prehistoric times of about 200 thousand years ago, to the bronze age. Adhesives made natural resources were used to craft tools, weapons and many other things. It was the most useful compounds in the old age days and in modern days too. In earlier days of about 6000 years ago glue was used in ceremonial and decoration items. It was also used for preparing axes and arrow tips. By world war several more types of natural glue were invented such as milk glue and nitrocellulose glues. In 1930s because of the rising chemistry and industries it was able to crack the secrets of plastics, rubber and synthetic glue. [1]

Adhesives are typically prepared by process of adhesion. Then they are categorized into reactive and non- reactive adhesives. This sort of adhesive, which is non-toxic and made from waste, could be used as an alternative source. It can also be categorized as whether the stock in its natural state is of usual or artificial origin, or by their preliminary physical phase. [2] There are few things in our surrounds which contains properties of adhesives. Around by us there are so many types of adhesives available in the market and they have gained stable position in an increasing number of production processes. In now a developed country like India, China, Russia or Brazil will cause for an increase in the demand for adhesives in the future.

As many environmental problems are becoming an issue people are concerned about the environment. Specially, People who has realise trash of solid waste like polystyrene has become serious problem for environment and it is causing many side effects. Polystyrene is non-biodegradable polymer it does not decompose for 100's of years and stops photosynthesis process. It also has a deleterious impact on the ozone layer and contributes to climate change. Polystyrene containers are used to carry food outside while travelling, but chemicals can leach into it which may infect the food, upsetting human health and reproductive systems. Its resilient to photolysis, or the contravention down of materials by photons creating from light. Styrofoam floats, as a result large amount of polystyrene is accumulated on the sea coasts across the world. It affects severely aquatic life and main component of marine debris. [4]

As considering all the concern and looking at the property of citrus fruits to dissolve the polystyrene in the citric acid extracted from the waste peels of the fruit which are thrown as waste in the food processing sector. The food industry where citrus fruits are being process to manufacture juices, jams, etc. this industry throw this peels as waste by utilizing this peels to extract citric acid and the manufacture the glue which totally non-toxic and fully safe to use and good glue stuff and being cheap as compared to other adhesives or glue in the market.

Literature survey

In early days' adhesive was learned in dominant Italy. It was found that it was used to joint two pebble flecks partly enclosed with birch-bark tar and third exposed pebble from the era circa 200,000 years ago. Human used tar-hafted stones in old days. [13] [2] The birch-bark-tar adhesive is a simple, one component adhesive. Here 70,000-year-old stone age segments such as axe which were once implanted in hafts which were covered with adhesive poised of plant gum and red yellowish-brown (normal iron oxide). It was found that adding yellowish-brown to plant gum increases the forte and products a tougher product and also protect the gum from disintegrating under wet conditions. [14] [2] In the middle age, as the human were making adhesive stronger the various types of new tools were developed. [15] [2]

The growth of contemporary adhesive and first profitable plant of glue began in 1690 in the Netherlands. This is a plant formed glue from animal hides. [16] [2] Next in 1750, first glue made throughout the United Kingdom patent was delivered for fish adhesive. When the first US postal stamps were introduced in 1847, they were made with starch-based adhesives. The First US patent on Dextrin adhesive was issued on 1867. [17] [2] In 1830, rubber from nature was utilised for the first time as an adhesive.. [18] [2] A British invention was issued in 1862 for electroplating metal with brass to achieve a stronger bind to rubber. [16] [2] Normal rubber-based gluey adhesives were used in cloth supported clinical and electrical adhesive tape. By 1925, the density delicate adhesive The tape industry was established. [12] [2] Today, PSAs include gummy notes, scotch tape, and other tapes.. [19] [2]

Waste citrus fruit skin was used which is freshly separated from the citrus fruits. Because fresh skin contains more amount of citric acid which we can use for saturation process, and thermocol is used for this process as this paper is based on recycling of polystyrene (Thermocol). Anti- bumping agents are also added in distillation feed to resist the bumpiness of feed material present in the flask.

Chemical bonding

Adhesive possess Superior heat stability, solvent resistance, excellent mechanical qualities, thermal diffusivity, low thermal expansion, implemented properly, hydrolytic stability, low dielectric constant, and high breakdown voltage are among the many superlative properties. These elevated polymers have a variety of enticing characteristics, making them excellent prospects for use as adhesives. [6]

So how does this relate to the many types of adhesive products that exist? In order for an adhesive to bond (hold together) two surfaces (substrates), Between both the sticky and both substrates, there should be a wide range of interactions.

Why simple distillation for the process?

Distillation is a technique for separate mixes in a boiling liquid combination based on the differences in constituent volatility. Distillation is a single-step process, not a chemical reaction, due to the fact that it is a physical separation method. Distillation has a variety of commercial applications.

To separate the components of air, it is distilled. Its components—notably oxygen, nitrogen, and argon—for industrial use. After synthesis, liquid compounds are frequently distilled to eliminate contaminants and unreacted starting ingredients for a variety of applications. Distillation of fermenting solutions has been employed to create distilled beverages with increasing alcohol content since ancient times. A distillery is a location where distillation, particularly alcohol distillation, takes place. [7]

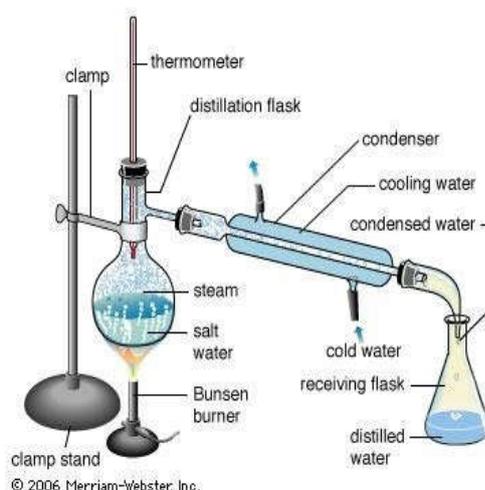


Fig1 : Simple Distillation Unit. [8]

In simple distillation, the vapour is immediately channelled into a condenser. As a result, the distillation is not pure; rather, its composition matches that of the vapours at the specified temperature and pressure. This concentration is governed by Raoul d's law.

As a result, simple distillation is only useful for removing liquids from non-volatile particles or oils when the liquid boiling points range substantially (The general rule is that the temperature should not exceed 25 degrees Celsius.). In these circumstances, the components' vapour pressures are usually sufficiently distinct that the distillate is pure enough for its intended use. [8]

Experimental Mechanism

Thermocol is basically polystyrene ($(\text{CH}(\text{C}_6\text{H}_5) - \text{CH}_2)_n$) by structure. Limonene is chemically a mixture of hydrocarbons which is citric acid is another name for it. When Thermocol is added to limonene, limonene acts as a solvent and dissolves Thermocol. We get a congealed mass when limonene is soaked with Thermocol, which is the adhesive. When we apply this glue to a surface, the paste's molecules stick to the surface. When we place another surface on the first one, these two surfaces stick together as the paste molecules bind to the second as well. Thus strong adhesive attraction was formed between the two surfaces due to strong adsorption and you end up with a thick gooey fluid. It's a natural occurrence, not a chemical one, and melting is involved from that created a very strong glue or adhesive. [9]

Method of production using Citrus fruit

- Firstly, remove the skin of citrus fruit and then crush or grind it to get zest.
- Carefully feed the zest the round bottom flask.
- Add distilled water to the flask.
- Add 5-10 anti-bumping granules.
- Then setup the distillation apparatus ensuring it is air tight and clamped properly.
- Heat the flask by using burner and collect the distillate in a cylinder for measuring.
- Stop heating when we get sufficient distillate and looks like there is less liquid present in the flask.
- Oil layer is formed at the very top of distillate.
- Separate the oil from the water using liquid-liquid extraction process.
- Measure the amount of oil/citric acid extracted from the process.
- Add the polystyrene/thermocool balls to the oil/citric acid till the solution get saturated and for a sticky solution which is our product Adhesive.

In this experimental procedure, take orange peels & crushed it into small particles and add water in it. Wash all the apparatus & arrange the distillation unit. While arranging the unit, first start the water flow of the condenser. Put the mixture of water & orange peels in a round bottom flask & add the anti-bumping granules in it and attach it to a condenser line. Place the thermometer on a top for measuring the vapour temperature. Start the heating. Heat the mixture for 1 hour to get sufficient distillate. Take care that mixture will not stick to a round bottom flask. Stop the heating after getting distillate in a receiver. Cool the flask with a circular bottom for 15 min. put the distillate in a measuring cylinder and measures its volume and density. Placed it in a separating funnel and allow it to settle and separate the top layer. Take a known weight of the Thermocol. The top layer is a limonene (orange oil). Add the Thermocol in a limonene till it gets saturated to give an adhesive. Note down the adhesive weight.

Aqueous solution melting and boiling points

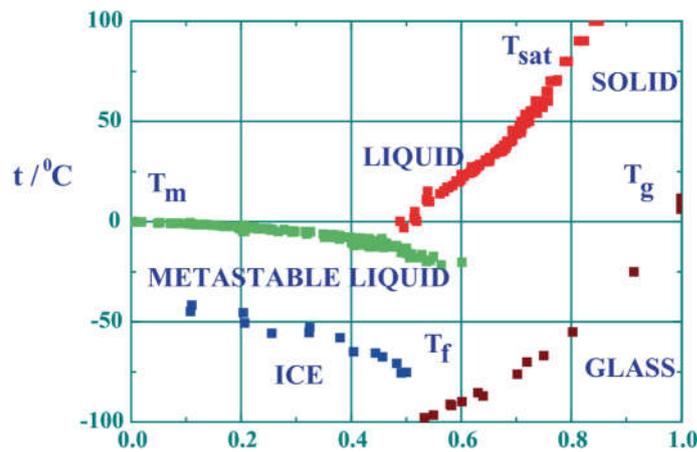


Fig.2. Phase diagram of the citric acid–water system. [19]

- - liquid–solid equilibrium (the solubility curve);
- - equilibrium melting curve;
- - homogenous ice freezing temperature curve;
- - the glass transition curve

Storage and handling

- Not damaged by low temperature condition in un-opened container.
- Maximum life of adhesive is achieved in a close container at a temperature of 2°-8°C. After its opening it is not recommended that the product should be kept in cold condition.
- After opening of a container it is best to be store in dry places and away from heat source or sun exposure.
- Humidity and heat decreases its shelf life.
- Shifting adhesive from one bottle to next can cause for the damage of its properties due to exposure in the air.
- These adhesives are sensitive to temperature and can solidify if heat is applied.

Properties

- Adhesion has an ability to hold two dissimilar materials and allows to bond strongly for long time.
- It has high cohesive strength.
- The strength can be improved by flexibility.
- The substrate's and adhesive's high elastic modulus resists stress at the bond line..
- The adhesive has a high damping capacity resists the dynamic vibration stress & impact stress on the bond & peeling the bond line's stress.
- Withstand physical shock at high temperatures.
- Retains its adhesive properties despite uv light, rain, sea water, and other environmental factors. but its starts to degrade with time after a long exposure. [20]

Application

Office and stationary uses

When it comes to stationery use they provide low bonding adhesive though their results are permanent. These glue can use for different types of papers like card board, poster board, and foam board. The glue tends to dry clear.

Decorative uses

Adhesives are used in lightweight materials like cardboard, paper, clothe, kids craft. Their carrier is usually water, which makes it simple to clean and low in toxicity.

Plywood industries

The blood albumen is used in plywood industry. These glues are made from serum albumen. The addition of water to the albumen increases the strength.

Mattress adhesive technology

It is use to hold mattresses layers together. Hot melt adhesive is being used for preparation of mattresses. This adhesive weekly form bond and solidify.

Fabric industries

It is use to bond two fabrics together or to decorate the fabric with artificial things such as artificial stones, lessees, diamonds, fabric flowers, etc.

Carpentry

The most common glue used in carpentry is yellow wood glue. The carpenter uses different types of glues. Basically three types of wood adhesive are present.

Type1- It has some water proof properties and it can be used for outdoor furniture and trim.

Type2- Does not perform well in external condition. Such adhesives tend to have longer open time and can better perform in colder conditions.

Type3- Designed for interior uses since it is not water resistance. [5]

Conclusion

This paper, as it proved that limonene, in specific fruit's peel, can be a good way to recycle Thermocol.

If orange peel essential oil and lemon peel oil were compared, orange peel oil has more limonene so it has a better ability to dissolve Thermocol.

By using limonene and polystyrene to make glue, we can create a more non-toxic adhesive that not only works well as well as promotes recycling.

The time consumption for the production of citric acid by using Extraction method is very less as comparing to other fermentation production methods.

This paper also proved that limonene will be a good eco-friendly solution for the ground pollution by thermocol, which does not decompose naturally. If the way of extracting peel oil from orange and lemon peel easily developed, people can use limonene from the peel in their house to recycle thermocol easily without wasting money and space for it. This idea should be given to all the people over the world, so they can recycle thermocol wisely in an eco-friendly way. By using limonene and polystyrene to make glue, we can create a more non-toxic adhesive that not only works well as well as promotes recycling.

Compared to previous results obtained in submerged culture and solid state fermentation method, the Extraction proved to be very versatile and did not need any additional nutrients or treatment.

References

1. <http://www.gluehistory.com/glue-origin/history-of-adhesives>
2. <http://en.m.wikipedia.org/wiki/Adhesive>
3. <http://www.sciencedirect.com/topics/agricultural-and-biological-sciences/citrus-fruits>
4. <http://green-mom.com/styrofoam-bad-environment/#.XHwSyW7hXqA>
5. <http://blog.mixerdirect.com/10-applications-for-adhesive-technologies>
6. <http://www.adhesive-and-glue.com/componentsof-adhesive-and-glues>
7. <http://www.einsten.net>
8. *Mass Transfer Operation* by Treybal, McGraw Hill
9. Antonio Pizzi, K.L. Mittal (01-Jan-1994) *Handbook of adhesive technology*. Page no.455-480
10. Pike, Roscoe. "adhesive" *Encyclopedia Britannica Online*.
11. Kinloch, A.J. (1987). *Adhesion and Adhesives: Science and Technology* (Reprinted. ed.). London: Chapman and hall p. 1.
12. *Adhesion And Adhesives: Science And Technology* January 1987, DOI: 10.1007/978-94-015-7764-9, Publisher: Chapman and Hall ISBN: 0-412-27440-X
13. Mazza, P; Martini, F; Sala, B; Magi, M; Colombini, M; Colombini, M; Giachi, G; Landucci, F; Lemorini, C; Modugno, F; Ribechini, E (January 2006). "A new Palaeolithic discovery: tar-hafted stone tools in European Mid-Pleistocene bone-bearing bed". *Journal of Archaeological Science*. 33 (9): 1310.
14. *Implications for complex cognition from the hafting of tools with compound adhesives in the Middle Stone Age, South Africa*, Lyn Wadley, Tamaryn Hodgskiss, and Michael Grant PNAS June 16, 2009 106 (24) 9590-9594; <https://doi.org/10.1073/pnas.0900957106>
15. Wadley, Lyn (1 June 2010). "Compound-Adhesive Manufacture as a Behavioral Proxy for Complex Cognition in the Middle Stone Age". *Current Anthropology*. 51(s1): S111-S119.
16. Pizzi, A. and Mittal, K.L. (2003) *Handbook of Adhesive Technology, Revised and Expanded*. CRC Press. <http://dx.doi.org/10.1201/9780203912225>.
17. *Handbook of Adhesives and Surface Preparation Technology, Applications and Manufacturing 1st Edition - December 15, 2010*
18. "Bonding-An Ancient Art". *Adhesives.org*. Adhesives and Sealants Council.
19. *Citric Acid - Alexander Apelblat* (Springer, 2014)
20. <http://www.adhesives.org/adhesives-sealants/adhesives-sealants-overview/structural-design/adhesive-properties>